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COMMENTS ON: PRINCIPLES OF INFORMATION RETRIEVAL BY MANFRED KOC--ETC(U)

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COMMENTS ON: *PRINCIPLES OF INFORMATION RETRIEVAL*  
by Manfred Kochen

Russell C. Coile

Professional Paper No. 215 ✓

March 1978

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(Published as a Letter to the Editor, Journal of Documentation,  
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# ABSTRACT

Mathematical errors in Manfred Kochen's book, Principles of Information Retrieval, give the reader the erroneous impression that the log-normal distribution is a better fit than Yule's Beta-function distribution for predicting frequency distributions of scientific productivity of econometricians and mathematicians. Correction of these errors suggests that the Beta function gives a better fit.



COMMENTS ON: PRINCIPLES OF INFORMATION RETRIEVAL

by Manfred Kochen

Kochen's<sup>(1)</sup> book, Principles of Information Retrieval, was recently reviewed in the Journal of Documentation by Vickery<sup>(2)</sup>. The review was concluded with the statement, "All who are concerned with the future development of information science will have something to learn from this book." Indeed, I learned a great deal while trying to sift out misinformation from information in the section called "Authorship." In view of the kind endorsement by a distinguished reviewer, I hesitate to sound a discordant note, but, in an effort to assist other readers who might have become confused by this section, may I point out some of the errors?

On page 85 of this book, Kochen makes the following statement:

"It is asserted (Learnes, 1953) for example, that the number of authors who published exactly  $r$  papers in Econometrica over a 20-year period is approximately  $a^{r-k}$ ."

First, the name was Dickson H. Leavens<sup>(3)</sup>, not Learnes. Second, he did not assert any formula. He did present a table of data giving the cumulative frequency distribution of contributors to Econometrica and a figure showing this cumulative number of contributors plotted versus the number of contributions on log-log graph paper. Leavens commented that the slope of the

straight line that he had drawn in freehand with what he termed "a fair fit for all but the last three points" was approximately -1.5, as he expected in accordance with Pareto theory.

Third, if he had presented a formula, it would certainly not have been  $a^{r-k}$  but would probably have been  $ar^{-k}$ . By curious coincidence, Sawyer<sup>(4)</sup> gives an example of a mistake remarkably similar to this one in his discussion of the detection of mathematical misprints. As a matter of interest, an expression based on all but the last three points is  $868r^{-1.56}$ . Fourth, this expression with Leavens' exponent of approximately -1.5 is for the cumulative number of authors who have contributed "at least  $r$ " papers in the Pareto sense, and the factors are not those for Kochen's "exactly  $r$ " papers in the Lotka<sup>(5)</sup> sense. For "exactly  $r$ " papers, we would have  $389r^{-1.94}$ , based on all but the last three data points.

On page 86, Table 4.1 purports to give the number of authors contributing  $r$  papers to Econometrica over a 20-year period. First, the column heading for  $r$ , which reads "11," is wrong. This should be "11 or more" or "greater than 10," but not simply "11." Second, all the numbers given, i.e., 824, 217, 94, 50, etc., are wrong. The correct numbers, as obtained from Leavens' Table I, are given in a proposal for a revised Table 4.1 for Econometricians at the end of this letter. Third, as a matter of interest to Sherlock Holmes fans, the numbers 824, 217, 94, 50, etc.,

are not for econometricians but are estimates of the number of physicists making important contributions in physics throughout history up to the year 1900. These estimates for physicists are to be found in a paper by Simon<sup>(6)</sup>. In Simon's paper, a column for "estimate" of physicists is adjacent to a column for "actual" econometricians, and was apparently copied by mistake. Fourth, as further evidence of the source of these erroneous numbers (824, 217, etc.), Simon's table only goes up to "11 or more" contributions, while Leavens' table goes right on up to 46 contributions.

On page 85, there is a statement:

"Some data has been compiled (Davis, 1941) to show that the number of authors, in a sample of authors who have written  $r$  papers, fits a Yule-type distribution."

First, Davis<sup>(7)</sup> never mentioned Yule or the Yule-type distribution. Harold T. Davis, a research associate of the Cowles Commission for Research in Economics, examined previously published data on scientific productivity of mathematicians, chemists, and physicists in an effort to find statistical support for his Pareto-type law of distribution of special abilities. Davis studied the data on scientific productivity of mathematicians published by Arnold Dresden<sup>(8)</sup>. Davis grouped Dresden's data into intervals of 7 centering on the central value, accumulated the number of authors, and fitted a parabolic curve to the accumulation obtaining:



$$\log y = 3.74877 - 2.11012 \log x$$

where  $y$  is the number of persons making at least  $x$  contributions. It should be noted that the slope Davis obtained of 2.11 was much larger than the normal 1.5 usually associated with the Pareto law.

Second, G. Udny Yule<sup>(9)</sup> developed a probability model in 1924 in connection with analysis of the distribution of biological genera by number of species. Herbert A. Simon studied this Beta-function model and proposed its possible application as a distribution function for scientific publications, calling it the "Yule" distribution. This was in 1955, some years after Davis' book was published in 1941.

Third, since Kochen neither described the "Yule" distribution nor referenced Simon's application of it to scientific productivity, it might be desirable for someone to explain what it is. Simon's "Yule" distribution is a Beta-function probability model,

$$f(i) = A B(i, \rho + 1)$$

where  $f(i)$  is the number of authors contributing a given number,  $i$ , of papers to journals

$A$  and  $\rho$  are constants and

$B(i, \rho + 1)$  is the Beta-function of  $i, \rho + 1$ .

In Simon's notation,



$$\rho = \frac{1}{1 + \alpha}$$

$$\text{where } \alpha = \frac{n_k}{k}$$

$n_k$  is total authors

$k$  is total papers

$$B(i, \rho + 1) = \int_0^1 \lambda^{i-1} (1 - \lambda^\rho) d\lambda = \frac{\Gamma(i) \Gamma(\rho + 1)}{\Gamma(i + \rho + 1)} \quad (0 < i, 0 < \rho < \infty) .$$

Simon derived the estimated frequencies from his equations (2.11) and (2.21) which are

$$\beta(i) = \frac{(1 - \alpha)(i - 1)}{1 + (1 - \alpha)i} = \frac{f^*(i)}{f^*(i - 1)} \quad (2.11)$$

$$(i = 2, \dots, k)$$

$$f^*(1) = \frac{k\alpha}{2 - \alpha} = \frac{n_k}{2 - \alpha} . \quad (2.21)$$

Fourth, Simon tested his Yule distribution on four sets of scientific productivity data which he had found published earlier by Davis and Leavens. This included Davis' collection of Dresden's data on mathematicians and Lotka's data on chemists and physicists as well as Leavens' data on econometricians. In Simon's paper, the seventh column of his Table 3 contained the Yule estimates of physicists which was adjacent to the eighth column which contained the actual numbers of econometricians, as was mentioned earlier.

On page 86, there is a statement,

"The log-normal distribution, on the other hand, gives a better fit than the Yule distribution to the data shown in Table 4.1."

First, Table 4.1 does not give estimates for mathematicians and econometricians calculated by either the log-normal distribution or the Yule distribution. It is impossible, therefore, to compare either estimates with the actual numbers of authors given. Second, there are no goodness-of-fit calculations given to support the opinion that the log-normal distribution is better than the Yule distribution. Third, Simon, in discussing qualitatively his Yule distribution, stated,

"The fit is reasonably good, when it is remembered that only one parameter is available for adjustment. However, it should be noted that the estimated frequencies tend to be too high for  $i = 1, 2$  and too low for  $i = 3, \dots, 10$ . In three of the four cases, they are again too high for the tails of the distributions. A further refinement of the model is apparently needed to remove these discrepancies."

Fourth, a proposed revision of Table 4.1, which includes the estimated Yule distribution for mathematicians, is given

below. Since Simon, for some unknown reason, did not provide a Yule estimate of the number of mathematicians making one contribution, a computer-generated Yule distribution is given as well as Simon's incomplete Yule distribution. A chi-square goodness-of-fit calculation has therefore been made using the computer's Yule distribution, which has a value of 31.5. For 7 degrees of freedom, the 0.05 level is 14.1, which shows that the Yule distribution is a poor fit, as Simon predicted. However, estimates of the log-normal distribution with  $\chi^2$  of 93.1 show it to be a terrible fit in contrast to Kochen's opinion that the log-normal was better than the Yule. Finally, a proposed revision of Table 4.1, to include the estimated Yule distribution for econometricians, is also given below. The computer's Yule estimates differ slightly from Simon's estimates. Again, the Yule fit is poor but better than the terrible fit of the log-normal estimates.



REVISED TABLE 4.1 FOR MATHEMATICIANS

| r          | Number of authors<br>contributing r<br>papers to the<br>Chicago Section<br>of American Math<br>Society over 25-<br>year period | Simon's<br>Yule<br>estimate | Computer's<br>Yule<br>estimate | Log-<br>normal<br>estimate |
|------------|--|-----------------------------|--------------------------------|----------------------------|
| 1          | 133  | -                           | 158.6                          | 66.6                       |
| 2          | 43   | 46                          | 47.7                           | 27.7                       |
| 3          | 24   | 23                          | 22.0                           | 15.8                       |
| 4          | 12   | 14                          | 12.4                           | 10.4                       |
| 5          | 11   | 10                          | 7.8                            | 7.3                        |
| 6          | 14   | 7                           | 5.4                            | 9.7                        |
| 7          | 5  | 5                           | 3.9                            |                            |
| 8          | 3  | 4                           | 2.9                            |                            |
| 9          | 9  | 3                           | 2.2                            | 8.4                        |
| 10         | 1  | 3                           | 1.8                            |                            |
| 11 or more | 23   | 30                          | 13.4                           | 19.4                       |
|            |  |                             | $\chi^2 31.5$                  | $\chi^2 93.1$              |

for d of f = 7

.05 level R:  $\chi^2 \geq 14.1$

REVISED TABLE 4.1 FOR ECONOMETRICIANS

| r          | Number of authors<br>contributing r<br>papers to<br><u>Econometrica</u> over<br>20-year period | Simon's<br>Yule<br>estimate | Computer's<br>Yule<br>estimate | Log-<br>normal<br>estimate |
|------------|--|-----------------------------|--------------------------------|----------------------------|
| 1          | 436  | 453                         | 453.4                          | 195.2                      |
| 2          | 107  | 119                         | 122.7                          | 74.9                       |
| 3          | 61   | 51                          | 52.3                           | 39.8                       |
| 4          | 40   | 27                          | 27.5                           | 24.5                       |
| 5          | 14   | 16                          | 16.5                           | 16.5                       |
| 6          | 23   | 11                          | 10.7                           | 20.5                       |
| 7          | 6  | 7                           | 7.4                            |                            |
| 8          | 11   | 5                           | 5.3                            |                            |
| 9          | 1  | 4                           | 4.0                            | 16.2                       |
| 10         | 0  | 3                           | 3.1                            |                            |
| 11 or more | 22   | 25                          | 18.1                           | 27.5                       |
|            |  | $\chi^2 23.9$               | $\chi^2 25.4$                  | $\chi^2 338.0$             |

for d of f = 8

.05 level R:  $\chi^2 \geq 15.5$

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